Course guide
230378 - GNSS - Big Gnss Data: From Remote Sensing to Space Weather

Last modified: 10/01/2024

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).
MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2022). (Optional subject).

Academic year: 2023 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here:
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here:
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

REQUIREMENTS

Basic knowledge of Mathematics and Physics (at the level of secondary education)

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE5. Ability to design radio-navigation and location systems, as well as radar systems.
CEE13. Ability to analyze and evaluate the performance at the physical level of the main devices and sensors, the relations between magnitudes in their terminals and their equivalent circuits.
CE15. Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as bioengineering, photovoltaic conversion, nanotechnology and telemedicine.

Transversal:
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

Application lectures
Expositive lectures
Personal work (non classroom)
Short-answer questions (Test)

LEARNING OBJECTIVES OF THE SUBJECT

To introduce the basic concepts of Remote Sensing and Space Weather with the Global Navegation Satellite Systems (GNSS), based on recent industry requirements and the direct use of new low-cost multi-GNSS multi-frequency receivers.

Learning outcome:
He/she expresses clearly the process of planning and solving exercises and problems that require the use of GNSS.
He/she understands and masters the most useful methods to solve problems in the area of this subject.
He/she addresses numerical description and formulation of problems with descriptive description.
He/she makes use of more than one source and uses it in a complementary manner to observe the events described in the main text.
He/she identifies problems and models from open situations and explores alternative resolutions.

STUDY LOAD

Type	Hours	Percentage
Hours large group	14,0	18.67
Self study	51,0	68.00
Hours small group	10,0	13.33

Total learning time: 75 h

CONTENTS

1) Introduction to GNSS

Description:
1.1 Concept, signals and formats
1.2 Segments
1.3 Basic and precise models

Related competencies :
CEE13. Ability to analyze and evaluate the performance at the physical level of the main devices and sensors, the relations between magnitudes in their terminals and their equivalent circuits.
CE15. Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as bioengineering, photovoltaic conversion, nanotechnology and telemedicine.
CE5. Ability to design radio-navigation and location systems, as well as radar systems.
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Full-or-part-time: 19h
Theory classes: 4h
Self study : 15h

GNSS tropospheric remote sensing

Description:
2.1 Tropospheric delay estimation with GNSS
2.2 Application to the monitoring of extreme weather events (hurricanes, sudden river rise)

Related competencies :
CEE13. Ability to analyze and evaluate the performance at the physical level of the main devices and sensors, the relations between magnitudes in their terminals and their equivalent circuits.
CE15. Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as bioengineering, photovoltaic conversion, nanotechnology and telemedicine.
CE5. Ability to design radio-navigation and location systems, as well as radar systems.
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Full-or-part-time: 10h
Theory classes: 2h
Self study : 8h

GNSS ionospheric remote sensing

Description:
content english

Specific objectives:
3.1 Ionospheric delay estimation with GNSS
3.2 Practical lectures of introduction to Linux and IonSAT-tools
3.2 Medium Scale Travelling Ionospheric Disturbances
3.3 Tsunami warning and monitoring

Related competencies :
CEE13. Ability to analyze and evaluate the performance at the physical level of the main devices and sensors, the relations between magnitudes in their terminals and their equivalent circuits.
CE15. Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as bioengineering, photovoltaic conversion, nanotechnology and telemedicine.
CE5. Ability to design radio-navigation and location systems, as well as radar systems.
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 21h
Theory classes: 2h
Laboratory classes: 8h
Self study : 11h

Space Weather with GNSS

Description:
4.1 Geomagnetic storm footprint in GNSS
4.2 Solar flare detection and measurement with GNSS
4.3 Achievement in Feb. 2020: Stellar flare detection and measurement with GNSS

Related competencies :
CEE13. Ability to analyze and evaluate the performance at the physical level of the main devices and sensors, the relations between magnitudes in their terminals and their equivalent circuits.
CE15. Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as bioengineering, photovoltaic conversion, nanotechnology and telemedicine.
CE5. Ability to design radio-navigation and location systems, as well as radar systems.
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Full-or-part-time: 22h
Theory classes: 4h
Laboratory classes: 2h
Self study : 16h

ACTIVITIES

Presentations of Academic ITT proposal

Description:
Presentations of the coursework based on GNSS Ionosphere and on available multi-GNSS receivers

Related competencies :
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 2h
Theory classes: 1h
Self study: 1h

Final exam

Description:
Final test

Full-or-part-time: 2h
Theory classes: 2h

GRADING SYSTEM

The assessment is based on:
a) The answers to the questionaire of the lab session at point unit 3 (20%)
b) The proposal the students have to submit individually (or in pairs) and defend (30%), as an answer to an "Academit Intended To Tender" (aITT) posed by the teacher, emulating the European Space Agency (ESA)
c) Final exam (50%).

In this subject the generic competences will be evaluated:
- Autonomous learning (Elementary level)
- Ability to identify, formulate and solve engineering problems (Elementary level)

BIBLIOGRAPHY

Basic:
- Graffigna, V.; Hernández-Pajares, M.; Gende, M.; Azpilicueta, F.; Antico, P. "Interpretation of the tropospheric gradients estimated with GPS during Hurricane Harvey". Earth and Space Science [on line]. Vol. 6, Issue 8, 1348-1365 [Consultation: 06/07/2020]. Available on: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018EA000527.- Hernández-Pajares, M.; García-Rigo, A.; Juan, J.M.; Sanz, J.; Monte, E.; Aragón-Àngel, A. "GNSS measurement of EUV photons flux rate during strong and mid solar flares". Space Weather [on line]. Vol. 10, Issue 12, 16 pp [Consultation: 06/07/2020]. Available on: https://agupubs-onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/10.1029/2012SW000826.- Hernández-Pajares, M.; Juan, J.M.; Sanz, J.; Aragón-Àngel, À.; García-Rigo, A.; Salazar, D.; Escudero, M. "The ionosphere: effects, GPS modeling and the benefits for space geodetic techniques". Journal of Geodesy [on line]. Vol. 85; 2011; pp. 887-907 [Consultation: 06/07/2020]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/article/10.1007/s00190-011-0508-5.- Yang, H., Monte Moreno, E., & Hernández-Pajares, M.. "ADDTID: an alternative tool for studying earthquake/tsunami signatures in the ionosphere: case of the 2011 Tohoku earthquake". Remote Sensing [on line]. Vol. 11, Issue 16, 2019, 1894:1-1894:23 [Consultation: 06/07/2020]. Available on: https://www.mdpi.com/2072-4292/11/16/1894.- Graffigna, V.; Brunini, C.; Gende, M.; Hernández-Pajares, M.; Galván, R.; Oreiro, F. "Retrieving geophysical signals from GPS in the La Plata River region". GPS Solutions [on line]. 23, 84 (2019), 7 pp [Consultation: 06/07/2020]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/article/10.1007/s10291-019-0875-6.- Cander, L.R. Ionospheric space weather [on line]. Cham: Springer Nature, 2019 [Consultation: 15/07/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5516524. ISBN 9783319993317.
- Teunissen, P.J.G.; Montenbruck, O. (Eds.). Springer handbook of global navigation satellite systems: with 818 figures and 193 tables [on line]. Cham: Springer International Publishing AG, 2017 [Consultation: 24/07/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=4880030. ISBN 9783319429281.
- Hernández-Pajares, M.; Juan, J.M.; Sanz, J.; Aragón-Àngel, A. "Propagation of medium scale traveling ionospheric disturbances at different latitudes and solar cycle conditions". Radio Science [on line]. Vol. 47, Issue 6, 2012, 22 pp [Consultation: 06/07/2020]. Available on: https://agupubs-onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/10.1029/2011RS004951.- Hernández-Pajares, M. Learning global navigation satetllite systems from actual data (LeGAD): Introduction to GNSS data processing: lecture notes [on line]. Barcelona: UPC-IonSAT, 1996-2015 [Consultation: 06/07/2020]. Available on: http://chapman.upc.es/lectures/legad/.
- Hernández-Pajares, M.; Moreno-Borràs, D. "Real-time detection, location, and measurement of geoeffective stellar flares from global navigation satellite system data: new technique and case studies". Space Weather [on line]. Vol. 18, Issue 3, 2020, 10 pp [Consultation: 06/07/2020]. Available on: https://agupubs-onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/10.1029/2020SW002441.- Yang, H.; Monte-Moreno, E.; Hernández-Pajares, M. "Multi-TID detection and characterization in a dense Global Navigation Satellite System receiver network". Journal of Geophysical Research: Space Physics [on line]. Vol. 122, Issue 9, 2017, 22 pp [Consultation: 06/07/2020]. Available on: https://agupubs-onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/10.1002/2017JA023988.- Teunissen, P.J.G.; Kleusberg, A. GPS for geodesy. 2nd rev. and extended ed. Berlin: Springer, 1998. ISBN 3540636617.

Complementary:
- Yang, H.; Monte Moreno, E.; Hernández-Pajares, M. "Detection and description of the different ionospheric disturbances that appeared during the solar eclipse of 21 August 2017". Remote Sensing [on line]. vol. 10, núm. 11, p. 1710:1 - 1710:24 [Consultation: 06/07/2020]. Available on: https://www.mdpi.com/2072-4292/10/11/1710.- Hernández-Pajares, M.; Wielgosz, P.; Paziewski, J.; Krypiak-Gregorczyk, A.; Krukowska, M.; Stepniak, K.; ... Orus-Perez, R. "Direct MSTID mitigation in precise GPS processing". Radio Science [on line]. Vol. 52, Issue 3, 2017, 17 pp [Consultation: 06/07/2020]. Available on: https://agupubs-onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/action/doSearch?AllField=Direct+MSTID+mitigation+in+precise+GPS+processing&SeriesKey=1944799x.- Monte-Moreno, E.; Hernández-Pajares, M. "Occurrence of solar flares viewed with GPS: statistics and fractal nature". Journal of Geophysical Research: Space Physics [on line]. Vol. 119, Issue 11, 2014, 12 pp [Consultation: 06/07/2020]. Available on: https://agupubs-onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/10.1002/2014JA020206.- Singh, T., Hernandez-Pajares, M., Monte, E., Garcia-Rigo, A., & Olivares-Pulido, G.. "GPS as a solar observational instrument: real-time

estimation of EUV photons flux rate during strong, medium, and weak solar flares". Journal of Geophysical Research: Space Physics [on line]. Vol. 120, Issue 12, 2015, 11 pp [Consultation: 06/07/2020]. Available on: https://agupubs-onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/10.1002/2015JA021824.